

SYNTHESIS OF ELONGATED MICROCAPSULES

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ABSTRACT

For self-healing functional materials, it is desirable to maximize the amount of liquid healing agents that can be delivered to the damaged area. The use of hollow tubes or fibers and the more sophisticated micro-vascular networks have been proposed as a way to achieve this goal [1-3]. Although these systems can be highly effective for some specific applications, they are not very practical for coatings applications. One possible practical way to increase the healing efficiency in coatings is to use microcapsules with high aspect ratios, or elongated microcapsules. It is understood that elongated microcapsules will be more efficient because they can release more healing agent than spherical microcapsules when a crack is initiated in the coating.

Although the potential advantage of using elongated microcapsules for self-healing applications is clear, it is very difficult to make elongated microcapsules from an emulsion system because spherical microcapsules are normally formed due to the interfacial tension between the dispersed phase and the continuous phase.

This paper describes the two methods that have been developed by the authors to synthesize elongated microcapsules: The first method involves the use of an emulsion with intermediate stability and the second involves the application of mechanical shear conditions to the emulsion.

In an emulsion with intermediate stability, the dispersed phase is constantly forming, deforming, breaking, and combining during the mixing process. If the continuous phase has a high viscosity, the dispersed phase will be deformed into elongated shapes that last long enough to form the capsule wall. Another contributing factor is that the size distribution of a less than stable emulsion is rather wide, which results in the formation of microcapsules of various sizes. The bigger microcapsules can also be broken after the capsule walls are formed and then form tail-like structures, as shown in Figure 1.

While it is possible to make elongated microcapsules using the first approach, the second approach is more effective and easier to control. This approach is based on the concept of the deformation of a single drop suspended in a second liquid phase where a simple shear is applied (Figure 2). Different experimental setups were tested to introduce a simple shear condition in the emulsion where the encapsulation process took place. Concentric cylinders and parallel plates have been proven to be effective in creating both elongated droplets and microcapsules. In both setups, the dispersed phase (liquid droplets with wall-forming prepolymer inside) was deformed under simple shear conditions. Then, a catalyst was added to trigger the polymerization reaction to form the capsule wall (Figure 3).

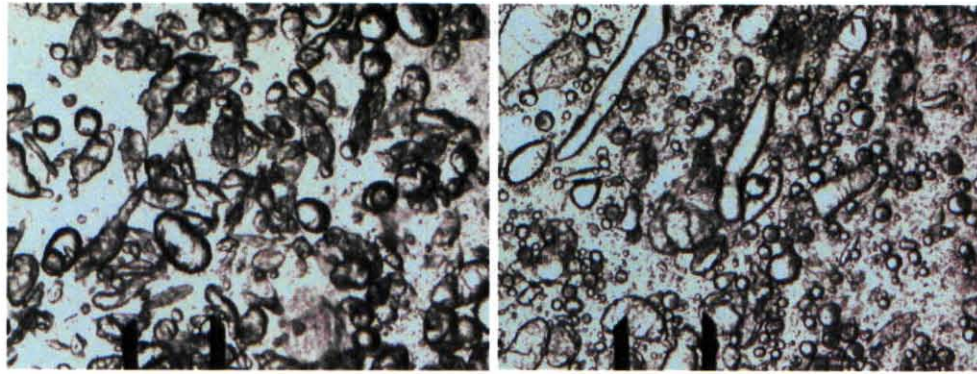


Figure 1: Elongated microcapsules synthesized in emulsion with intermediate stability.

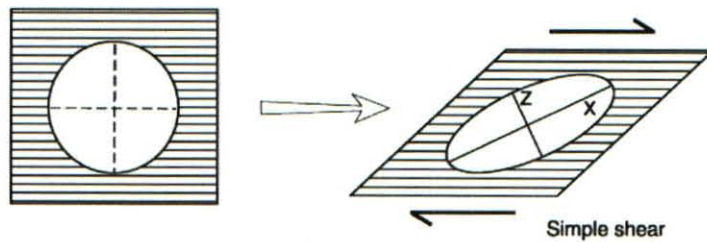


Figure 2: A spherical liquid drop deforms under a simple shear condition.

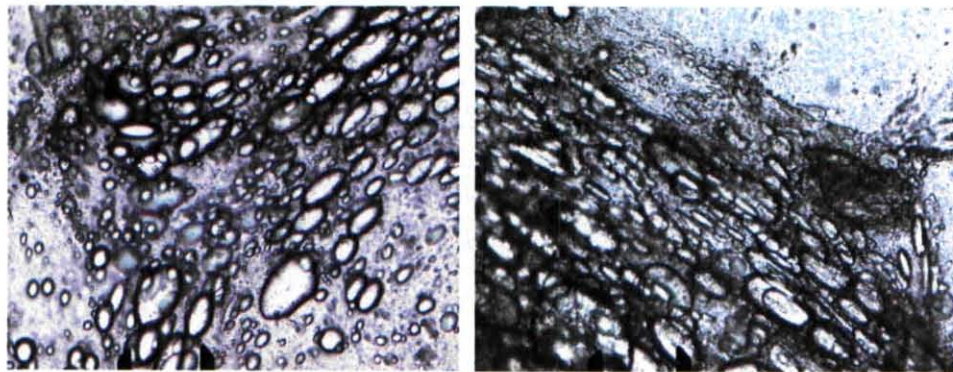


Figure 3: Elongated microcapsules synthesized under simple shear condition.

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SYNTHESIS OF ELONGATED MICROCAPSULES FOR SELF-HEALING MATERIALS

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One of the factors that influence the effectiveness of self-healing in functional materials is the amount of liquid healing agents that can be delivered to the damaged area. The use of hollow tubes or fibers and the more sophisticated micro-vascular networks has been proposed as a way to increase the amount of healing agents that can be released when damage is inflicted. Although these systems might be effective in some specific applications, they are not practical for coatings applications. One possible practical way to increase the healing efficiency is to use microcapsules with high-aspect-ratios, or elongated microcapsules. It is understood that elongated microcapsules will be more efficient because they can release more healing agent than a spherical microcapsule when a crack is initiated in the coating.

Although the potential advantage of using elongated microcapsules for self healing applications is clear, it is very difficult to make elongated microcapsules from an emulsion system because spherical microcapsules are normally formed due to the interfacial tension between the dispersed phase and the continuous phase.

This paper describes the two methods that have been developed by the authors to synthesize elongated microcapsules. The first method involves the use of an emulsion with intermediate stability and the second involves the application of mechanical shear conditions to the emulsion.